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Currency Unions and Trade: Variations on Themes by Rose and Persson

Peter B. Kenen

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Abstract[1]

Using a gravity equation, Andrew Rose finds that currency-union countries trade more intensively with each other than do other country pairs, and others report same result. Using a nonparametric test, however, Persson finds that trade flows between currency-union countries are not significantly different in size from other bilateral trade flows. Using another way to identify a currency-union country, this paper reproduces Persson's result but also produces an anomaly. When Rose's gravity equation is re-estimated using the data set furnished by the alternative definition of a currency-union country, Rose's result survives, although the currency-union effect is smaller than the effect he reported initially.

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1 Introduction

In a path-breaking paper, Rose (2000) used an augmented gravity equation to show that trade between countries sharing the same currency is much larger than trade between other pairs of countries. His cross-sectional regression results imply that the bilateral trade between two currency-union countries is, on average, 3.35 *times* as large as the bilateral trade between other countries. In language used hereafter, the *trade-raising effect* of a currency union is 235 per cent, and this is additional to the most obvious trade-raising effect of a currency union – the complete suppression of exchange-rate variability.[2] A subsequent paper by Glick and Rose (2002) presented time-series regression results that ratified Rose's finding; it showed that the formation and dissolution of currency unions had large, long-lasting effects on the bilateral trade between the relevant country pairs. Rose (2002) has since surveyed the results of 19 recent studies and has found that they imply a substantial trade-raising effect, although smaller than the one he obtained originally; the composite estimate of the trade-raising effect obtained from those 19 studies is roughly 100 per cent.[3]

[2] Earlier work by McCallum (1995) and others showed that national borders have strong trade-reducing effects and also produce large differences between international and interregional deviations from the law of one price. Those studies did not identify explicitly the contribution of the exchange-rate regime or exchange-rate variability. See, however, Parsley and Wei (2001), who showed that part of the "border effect" on the deviations from the law of one price are explained by the variability of the nominal exchange rate. It should be noted, however, that the measures of exchange-rate variability usually used in empirical work focus primarily on short-run exchange-rate volatility. They do not fully reflect uncertainty about the longer-term path of the exchange rate Yet the risk of large, long-lasting exchange-rate changes may have a stronger trade-reducing effect than the risk of short-term fluctuations, because it is far harder to hedge against them. (This observation also suggests that Rose's currency-union dummy may be reflecting the main effect of a currency union; it banishes the risk of large, long-lasting exchange-rate changes.)

[3] This composite estimate derives from the mean of the first four currency-union coefficients in Table 3 of Rose (2002). Some of the 19 studies surveyed do not provide explicit regression estimates of the currency-union coefficient, but Rose transforms their findings into equivalents of regression estimates.

Several authors have noted, however, that the currency unions covered by Rose's original study involve small, low-income countries. Some of them belong to the currency unions of Francophone Africa (e.g., Benin and Cameroon) or the Eastern Caribbean Currency Area (e.g., Dominica and Grenada); others are small developing countries that have adopted the currencies of large industrial countries (e.g., Panama, which uses the US dollar).[4] For this and other reasons, Persson (2001) suggested that the bilateral trade of the currency-union pairs may be atypical and cannot readily be compared with the bilateral trade of all other country pairs; they should instead be compared with the bilateral trade of a subset of similar country pairs. Therefore, he used a matching approach to choose country pairs that are most closely comparable to the currency-union pairs, and he found that the mean of the trade flows between the currency-union pairs is not significantly different from the mean of the trade flows between the other country pairs that formed his comparison group.

Persson's approach is attractive, but I have reservations about the way he chose his comparison group, and I use different method in this paper. My main result is similar to the one he obtained. The mean of the trade flows between the currency-union pairs is not significantly different from the mean of the trade flows between the country pairs that form my comparison group. But when I return to Rose's gravity equation, I obtain a different, anomalous result. When Persson re-estimated that gravity equation using the subset of country pairs comprising his currency-union pairs and his comparison group, he found that the currency-union coefficient was not significantly different from zero – a result consistent with his finding regarding the means of the trade flows for the two groups of country pairs. But when I re-estimate that gravity equation using the subset of country pairs comprising my currency-union pairs and my comparison group, I obtain a significant currency-union coefficient. I short, I confirm the main result obtained by Persson using his

[4] See, however, Micco, Stein, and Ordoñez (2002), who examine the effects of the introduction of the euro in 1999 and find that it has had a small but significant trade-raising effect. Rose's results, then, may not be due to the characteristics of the currency-union countries covered by his study.

nonparametric test, but I also confirm the main result obtained by Rose using his parametric test.

2 The Rose gravity equation

Rose's gravity equation for 1990 is reproduced in the first column of Table 1. The dependent variable is the log of the sum of the trade flows between countries i and j. The regressors are those defined and used by Rose:

- The first regressor is the currency-union dummy, which is set at unity if countries i and j shared a common currency in 1990 (and is zero otherwise).

- The second regressor measures the month-to-month variability in the nominal exchange rate between the currencies of countries i and j during the five years before1990.

- The next three regressors are those commonly used in gravity models that aim at explaining the volume of trade between countries i and j: the log of the product of their gross domestic products, the log of the product of their gross domestic products per capita, and a measure of the distance between countries i and j.

- The remaining regressors are dummy variables, defined as follows:

  a. Contiguity is set at unity if countries i and j have a common border.

  b. Common language is set at unity if they share a common language.

  c. Common FTA is set at unity if they belonged to the same free trade area in 1990.

d. Same nation is set a unity if one was a dependency or political subdivision of the other in 1990, or both were dependencies or subdivisions of the same third country.

e. Common colonizer is set at unity if both countries were colonies of the same third country after 1945.

f. Colonial relationship is set at unity if one country colonized the other.

All but one of the regression coefficients are statistically significant at the 0.01 level and have the expected signs. Rose's main result, however, pertains to the statistical significance and large economic size of the coefficient on the currency-union dummy. As the dependent variable is the log of the level of trade between countries i and j, that regression coefficient says that, all else being equal, the trade between two countries that share a common currency will be 4.52 *times* as large as the trade predicted by the other arguments of the gravity equation. In other words, the trade-raising effect of a currency union is 352 per cent – the number shown at the bottom of Table 1. (This number is larger than the one cited in the introduction, which pertains to Rose's pooled regression for 1970, 1975, 1980, 1985, and 1990. Rose's single-year regressions suggest, indeed, that the currency-union effect has risen through time.)

Rose's data set contains 186 countries (see his Table A2), but there are many gaps in his output and exchange-rate data. I filled several of those gaps, using the same data bases cited by Rose, and was able to raise the number of usable country pairs, but I had to delete the country pairs involving South Korea, because of an error in the exchange-rate data. I also corrected a few coding errors, including those mentioned on own Rose's website.[5] Finally, I recoded Rose's common-language dummy using the listing of national languages at www.ethnologue.org.

My modified version of Rose's data set covers 121 countries and dependencies; they are listed in Table A1. I have used that data set to

[5] Smith (2002) draws attention to other coding problems that I have not addressed.

obtain a revised version of Rose's equation. It appears in the second column of Table 1.[6] The coefficients of the revised equation are not much different from those of Rose's equation, but the trade-raising effect is bigger; it rises from 352 per cent in Rose's equation to 461 per cent in my revised equation. The remaining equations in Table 1 are discussed later in this paper.

3 The question of comparability

Critics of Rose's work have suggested that two countries are more likely to share a single currency if they have other features in common, including the features defined by the other dummy variables used in Rose's own equation. The correlation matrix in Table A2 gives some support to this conjecture. The currency-union dummy is positively correlated with four other dummy variables, including the same-nation dummy.[7] (In fact, every same-nation pair represents a currency union, because all of the dependencies and political subdivisions in Rose's data set use their parent countries' national currencies.) Nevertheless, a probit equation linking the currency-union dummy to all of the other dummy variables used in the gravity equation explains less than 40 per cent of the variance in the currency-union dummy (and when the same-nation pairs are dropped from the data set and the same-nation dummy is also dropped from the set of regressors, the probit equation explains an even smaller portion of the variance in the currency-union dummy).

Persson (2001) raises a stronger objection to Rose's strategy: the large amount of trade between the currency-union country pairs may reflect

[6] If each the 121 countries traded with every other country, the revised equation would cover the trade of 7,260 country pairs. But no country trades with every other, and many have only a handful of partners. Therefore, the actual number of country pairs shown beneath the revised equation is far smaller than 7,260 (although slightly larger than the number of country pairs used in Rose's own equation).

[7] Note in passing, however, the negligible correlation between the currency-union and colonial-relationship dummies. It small size reflects the fact that only one country in Rose's data set for 1990 uses the national currency of its former colonizer. (See also Table A4, below, where the colonial-relationship dummy has the wrong-signed coefficient in Persson's logit equation and is omitted entirely from my probit equation.)

other "unaccounted-for-differences between the groups of country pairs that do and do not use a common currency." In particular, he says, "the characteristics shaping trading costs may be very different for countries that do and do not share a common currency." Therefore, he uses a matching approach to compare the bilateral trade of the currency-union country pairs and the bilateral trade of country pairs that are "appropriately similar" to the currency-union pairs. He treats two country pairs as being "appropriately similar" if, in the absence of a currency union, the currency-union pair would have the same amount of bilateral trade as the other country pair (Persson, 2001, p. 439).

To pursue this approach, Persson adopts a standard two-step strategy. First, he estimates a logit equation aimed at predicting the probability (the so-called *propensity score*) that a particular country pair will have a common currency, using as regressors nine of the other explanatory variables that appear in Rose's gravity equation.[8] Next, he uses two methods to form his comparison groups:

1. The *stratification method*, which ranks the currency-union pairs by their propensity scores, divides them into subgroups, sorts the other country pairs into those same subgroups using their propensity scores, then treats those other pairs as the comparison group. This method yields a trade-raising effect of only13 per cent, which is not statistically significant.

2. The *nearest-matching method*, which twins each currency-union pair with the other country pair having the propensity score closest to that of the currency-union pair, then treats those closest country pairs as the comparison group. This method yields a trade-raising effect of 66 per cent, which is slightly short of statistical significance.

Persson also re-estimates Rose's gravity equation using as his data set the country pairs obtained by the nearest-matching method – the currency-union pairs and comparison-group pairs – and finds that the currency-union coefficient is not significantly different from zero. (He does not provide a re-estimate of the gravity equation using as his data set the country pairs obtained by stratification method.)

[8] He rightly omits the exchange-rate variability term, because it is a perfect predictor of the currency-union dummy; there is no exchange-rate variability within a currency union. Persson's logit equation appears in the first column of Table A4.

Persson explains that his logit equation is not meant to provide a statistical or economic explanation of currency-union membership. It is merely a "legitimate" way to match country pairs having identical trading costs, as defined by the nine other regressors in Rose's gravity equation. There are, however, two objections to his methodology. First, the regressors include GDP and GDP per capita, which may not have much bearing on trading costs *per se;* they appear in the standard gravity equation for quite different reasons. Second, the propensity scores provided by his logit equation *are*, in fact, estimates of the probability that a particular country pair will share a common currency, and Persson himself assesses the quality of his logit regression results from that very standpoint.

When viewed from that standpoint, however, Persson's approach can be seen to derive from a rather restrictive assumption. Because his propensity scores attach to country pairs, he is implicitly assuming that the measured characteristics of the two countries comprising a country pair serve jointly and symmetrically to determine the probability that this country pair will have a common currency. Yet Panama's decision to adopt the US dollar may have more to do with Panama's characteristics (and, perhaps, the attributes of the US dollar) than with the characteristics of the United States. Furthermore, Persson's approach does not distinguish between two types of currency-union pairs: those that reflect a country's decision to enter a currency union, such as Panama's decision to adopt the dollar, and those that are merely by-products of that decision, such as Panama's currency unions with the Bahamas and Barbados, which have also adopted the dollar.[9]

[9] Alesina, Barro, and Tenreyro (2002) draw this same distinction. They estimate the probability that Panama will adopt the U.S. dollar and the probability that Barbados will do so. They then use those probabilities to estimate the probability that Panama and Barbados will have a dollar-based currency union.

I adopt a different, asymmetrical approach. I use a probit equation to estimate the probability that a particular country will deliberately adopt some other country's currency or join a multilateral currency union such as the Eastern Caribbean Currency Area or one of the African currency unions based on the CFA franc. Thereafter, I use a simple analogue to Persson's stratification method in order to form a comparison group of country pairs resembling the currency-union pairs. Hereafter, I call this a *country-based* strategy, in order to distinguish it from Persson's *trade-based* strategy.[10]

4 Pursuing the country based strategy

To pursue this country-based strategy, I must first redefine the currency-union dummy. It is set at unity for a country such as Panama, which uses the US dollar, but it is set at zero for the United States.[11] Similarly, it is set at unity for Nauru, which uses the Australian dollar but is set at zero for Australia. In the case of a multinational union, however, the currency-union dummy is set at unity for every member country, on the implicit supposition that the decision to join – or defect – resides with each country individually. I must also define a new set of single-country regressors to use with my single-country currency-union dummy:

- Output per capita is the log of the i^{th} country's gross domestic product per capita.

[10] I do not go on to use the nearest-matching method, for two related reasons. First, a single country (The Seychelles) is the nearest match to all of the 15 currency-union countries with the highest propensity scores. Furthermore, 18 of the 32 countries that form the comparison group under the stratification method (those with propensity scores no lower than 0.05) are omitted by the nearest-matching method; the remaining 14 countries are the nearest matches to the 34 currency-union countries. Therefore, the comparison group becomes very small.

[11] Rose and Engel (2000) use the same rule when surveying the characteristics of currency-union countries. They exclude from the group of currency-union countries the large industrial countries that issue the currencies used by their currency-union partners.

- Population is the log of the country's population.

- Ex-colony is a dummy variable set at unity if the country was another country's colony through 1955 but achieved independence thereafter.[12]

- Ex-colony or dependency is a dummy variable set at unity if the country was another country's colony through 1955 or was still a dependency of another country in 1990.[13]

- Export concentration is the share of the country's exports going to its largest single customer.[14]

- Openness is the ratio of the country's trade in goods and services (exports *plus* imports) to its gross domestic product.

- Member of FTA is a dummy variable set at unity if the country belonged to one of the free trade areas covered by Rose's data set.

- Island is a dummy variable set at unity if the country is an island.

There are, of course, no single-country analogues to the distance, contiguity, common-language, and common-colonizer dummies used in Rose's gravity equation.

Using the variables defined above, I ran several probit equations to account for the cross-country variation in the currency-union dummy and

[12] The 1955 cut-off date used for this variable is different from the one used by Rose but proved to be more satisfactory than other cut-off dates.

[13] This is, in effect, the sum of the ex-colony dummy defined above and a single-country version of the same-nation dummy used in Rose's gravity equation.

[14] When the USSR was a country's largest customer in 1990, exports to the USSR were excluded from the country's total exports, and export concentration was measured using the country's exports to its next-largest customer. In the case of Hong Kong, exports to China were excluded, and export concentration was measured analogously.

thus provide a different way to estimate the probability (propensity score) that a particular country will belong to a currency union. Four of those probit equations appear in Table 2.[15] The first three equations use the largest available data set; it covers the 121 countries and dependencies that form the bilateral (country-pair) data set used to obtain the revised Rose equation in Table 1 *plus* 27 other countries that could not be included in the bilateral data set because of missing observations but could nevertheless be added to the country data set.[16] The final equation in Table 2 uses a smaller group of countries –the 121 countries and dependencies that appear in the revised version of Rose's trade data set.

There is no need to discuss these equations at length. It is sufficient to note that output per capita, population, ex-colony or dependency, and export concentration take on the expected signs in Equations 3 and 3a and are statistically significant at the 0.05 level (except for export concentration in Equation 3a, where it is slightly below significance). By contrast, the last three variables in Table 2 fell short of significance whenever they were used and were therefore omitted from Equations 3 and 3a. Equation 3a was therefore used to produce propensity scores for the 121 countries included in the bilateral data set, and the distribution of those scores is given in Table 3.[17]

Two features of Table 3 deserve attention. First, the upper tail of the distribution for the currency-union countries is very thick; 14 of the 34 currency-union countries have propensity scores no lower than 90 per

[15] Some of the other probit equations used GDP in lieu of population, and some used various subsets of the export-concentration, openness, and FTA-membership variables.

[16] The eight dependencies, however, are excluded from Equations 1and 2 because their propensity scores are unity whenever the dependency dummy is added separately to one of the probit equations. (As all of the eight dependencies belong to currency unions, they can be included in these probit equations only when the dependency dummy is combined with the ex-colony dummy, as in Equations 3 and 3a.) Two more countries are excluded from Equation 1, because of missing data on their trade in goods and services.

[17] Equation 3 was likewise used to obtain propensity scores for the 148 countries and dependencies in the larger data set; and the distribution of the corresponding propensity scores is given in Table A3.

cent. Second, the lower tail of the distribution for the other countries is likewise very thick; 55 of the 87 other countries have propensity scores lower than 5 per cent. This difference between the distributions of the two country groups underscores a point made by Rose's critics. The currency-union countries covered by his study are indeed atypical, and it is therefore imprudent to use Rose's regression results to predict the trade-raising effects of hypothetical currency unions involving other groups of countries. Note, in particular, that all 12 members of the European monetary union have propensity scores lower than 5 per cent, and eight of those have propensity scores lower than 0.1 per cent. If they had been currency-union countries in 1990, the probit equations in Table 2 might have looked quite different and might therefore have generated rather different distributions. It may even be misleading to compare the currency-union countries listed in Table 3 with other groups of countries, even those with similar propensity scores. I nevertheless make two such comparisons here:

- In the first comparison, the 34 currency-union countries comprise the so-called treatment group. The corresponding comparison group comprises the 32 "other countries" shown in Table 3 as having propensity scores no lower than 5 per cent. These two groups of countries are described hereafter as Treatment Group A.

- In the second comparison, 19 currency-union countries comprise the treatment group; they are the currency-union countries (other than New Caledonia) having propensity scores lower than 90 per cent.[18] The corresponding comparison group is the same one used for Treatment Group A, comprising the 32 "other countries" having propensity scores no lower than 5 per cent. These two groups of countries are described hereafter as Treatment Group B.

[18] In effect, I drop from Treatment Group A every currency-union country and dependency that has a propensity score higher than that of any country that does not belong to a currency union, but I also exclude New Caledonia, because it would otherwise be the only dependency in Treatment Group B.

Clearly, the first comparison involves an imperfect matching of currency-union countries and comparison-group countries; 14 of the 34 currency-union countries in Treatment Group A have higher propensity scores than any of the 32 countries in the common comparison group. But the number of currency-union countries in Treatment Group B is rather small, although they may be more closely matched with the common comparison group. It should also be noted that there are big differences between the currency-union groups on the one hand and the common comparison group on the other. In Table 4, both groups of currency-union countries are shown to have smaller gross national products and smaller populations than the ones comprising the common comparison group. Furthermore, the currency-union countries in Treatment Group A show, on average, greater export concentration than those in the common comparison group. The various groups, however, do not differ much in openness, and they have similar levels of gross domestic product per capita.

Next, I choose the country pairs corresponding to Treatment Group A. To that end, I return to the revised version of Rose's data set and delete all bilateral trade flows that do not involve at least one of the currency-union countries in Treatment Group A or one of the countries included in the common comparison group, but I do not delete any other trade flow. For example, I delete US trade with Ireland but do not delete US trade with Panama, which belongs to the currency-union group, or US trade with Hong Kong, which belongs to the common comparison group. Nor do I delete Panama's trade with Hong Kong or Hong Kong's trade with Costa Rica. I am left then with 63 observations involving bilateral trade between two currency-union countries, such as Panama's trade with the United States, and 2,818 observations representing other trade flows involving countries included in Treatment Group A.[19]

[19] These include five types of trade flows: (1) trade between countries belonging to different currency unions, such as Panama and Mali; (2) trade between a currency-union country and an excluded country, such as Panama and Ireland; (3) trade between a currency-union country and a comparison-group country, such as Panama and Hong Kong; (4) trade between a comparison-group country and an excluded country, such as Hong Kong and Ireland; and (5) trade between a pair of comparison-group countries, such as Hong Kong and Costa Rica.

To choose the country pairs corresponding to Treatment Group B, I go on to delete all bilateral trade flows involving the 15 currency-union countries excluded from Treatment Group B that do not also involve one of the currency-union countries remaining in that treatment group or one of the countries included in the common comparison group. For example, I delete Reunion's trade with Ireland and Guadeloupe, but do not delete its trade with Panama or Hong Kong. At the end of this additional step, I am left with 39 observations representing bilateral trade between currency-union countries, and 2,463 observations representing other trade flows involving countries in Treatment Group B.

Finally, I use these data sets to compute and compare the means of the logs of the trade flows between the pairs of countries that share a single currency and the means of the logs of the other trade flows – those that involve a currency-union or comparison-group country but do not involve two members of the same currency union. The results are shown in Table 5. The differences between the means are very small and even have opposite signs. Therefore, they say that currency unions have no trade-raising effect.

5 The anomaly

When I re-estimate Rose's gravity equation using the country pairs contained in Treatment Groups A and B, I obtain the third and forth equations shown in Table 1. Although the trade-raising effects are smaller than the one obtained from the revised Rose equation, the currency-union coefficients are still significant.[20] When Persson performed the same experiment, however, using his nearest-matching method, the currency-union coefficient was not significant, even at the 0.05 level.[21] Why do my

[20] There are very small differences between the numbers of observations shown in Table 5 and at the foot of the corresponding gravity equations in Table 1. Two observations were inadvertently omitted from the re-estimation of the gravity equation. The difference, however, is too small to affect the regression results.

[21] See Equation (3) in Persson (2001), Table 4.

results differ from Persson's? There may be three reasons for this anomaly.

First, my results are based on Rose's 1990 data set, whereas Persson's results are based on Rose's five-year data set. As the currency-union coefficient is larger in Rose's 1990 equation than in his five-year pooled regression, I am perhaps more likely to obtain a large currency-union coefficient.

Second, my results derive from my country-based strategy, whereas Persson's results derive from his trade-based strategy. Although those strategies yield identical groups of currency-union country pairs, they are apt to yield different comparison groups. My comparison group necessarily excludes a particular country pair if both of the countries involved are listed in Table 3 as having propensity scores lower than 5 per cent. Conversely, it necessarily includes a country pair if both of the countries involved have propensity scores higher than 5 per cent. Persson's comparison group, by contrast, does not exclude any country pair unless the pair itself has a low propensity score.

Third, I obtain my gravity equation using the country pairs selected by the stratification method, whereas Persson obtains his gravity equation using the country pairs selected by the nearest-matching method, and Persson himself suggests that this may explain why his currency-union coefficient is not statistically significant. In his view, the nearest-matching method provides a better-balanced data set than the stratification method, because the number of comparison-group country pairs obtained by the nearest-matching method resembles the number of currency-union country pairs and does not dominate the re-estimation of the gravity equation.

6 Tracking the anomaly

It is not easy to assess the power of the first two explanations but fairly easy to assess the power of the third. Persson does not furnish a gravity equation using the country pairs selected by the stratification method, and I have not furnished one using the country pairs selected by the nearest-matching method.[22] It is nevertheless possible to generate trade-based propensity scores for 1990 that are roughly comparable to the five-year trade-based propensity scores that Persson used to form his comparison group. Those scores can then be employed to mimic Persson's use of the stratification method and the nearest-matching method.

To begin, I estimate a trade-based probit equation for 1990 resembling the trade-based logit equation from which Persson obtained his propensity scores. Next, I use that probit equation to compute a propensity score for each country pair. Finally, I use those propensity scores to form the relevant groups of country pairs. (The probit equation appears in Table A4, and the distribution of propensity scores appears in Table A5.)

To mimic Persson's use of the stratification method, I lop off all of the country pairs having propensity scores smaller than the lowest score for a currency-union pair and thereby obtain a data set comprising the 63 currency-union pairs previously used in Table 5 *plus* a new comparison group comprising 1,429 other country pairs. The differences between the means of the country-pair characteristics appear in the upper part of Table 6, and the corresponding gravity equation appears in the first column of Table 7. The two groups of country pairs are not quite alike, but the means of their trade flows are not very different. The gravity equation, however, has a highly significant currency-union coefficient; the trade-raising effect of a currency union amounts to 181 per cent.

To mimic Persson's use of the nearest-matching method, I search for the country pair that has the propensity score closest to that of each currency-union pair. Like Persson, I find that several country pairs must do double duty, because their scores are closest to those of two or more currency-

[22] For my reasons, see note 10 above.

union pairs. (One such country pair is indeed the nearest match to 18 currency-union pairs.) Therefore, my data set comprises the 63 currency-union pairs but only 32 comparison-group pairs. The differences between the means of the country-pair characteristics appear the lower part of Table 6, and the corresponding gravity equation appears in the second column of Table 7. The two groups of country pairs do not differ as much as those obtained by the stratification method, and the means of their trade flows are very similar. In this case, moreover, the currency-union coefficient in the gravity equation is not significantly different from zero. (It is somewhat smaller in size and has a larger standard error.)

The results produced by my country-based approach are thus broadly consistent with those produced by Persson's trade-based approach: (1) We find no significant difference between the relevant means – the average amount of trade between the currency-union pairs and the average amount of trade between the comparison-group pairs. (2) Persson does not furnish the gravity equation corresponding to his use of the stratification method, but when I mimic his trade-based approach using 1990 data, I obtain a gravity equation with a significant currency-union coefficient, which is what I found when I used my country-based approach. (3) I do not furnish the gravity equation corresponding to my use of the nearest-matching method, but when I mimic Persson's trade-based approach using 1990 data, I find that the currency-union term is not statistically significant, which is what Persson found when he use Rose's five-year data set. I have thus to conclude that the difference between our approaches does not explain the anomaly. It crops up consistently in computations based on the stratification method but not in computations based on the nearest-matching method.

7 Conclusion

Persson gives two reasons for testing the strength of the currency-union effect by comparing the means of the relevant trade flows rather than using a gravity equation with a currency-union dummy. First, currency-union country pairs may differ from other country pairs in ways that are not captured by a gravity equation. Persson's approach, adopted here, deals with this problem by selecting a subset of country pairs that resemble the currency-union pairs. Persson's approach and my own differ only in the way they form the comparison group. Second, the gravity equation may be imperfectly specified. Persson himself detects a nonlinear relationship between the amount of bilateral trade and the gross national products of the trading countries, and he shows that neglect of this relationship imparts an upward bias to the currency-union coefficient of the gravity equation. One might therefore expect the gravity equation to display a significant currency-union effect even when the amount of trade between the currency-union pairs does not differ significantly on average from the amount of trade between other, comparable country pairs.

In his reply to Persson, Rose (2001) suggests that Persson's nonparametric test fails to find a significant currency-union effect because it discards much of the relevant information used in Rose's gravity equation – information about country size and income, the distance between the members of a country pairs, whether the members also belong to the same free-trade area, share a common language, and have – or had – close political links, such as a common colonizer. But Persson's approach and my own do not really discard all of this information. Some of it is used to produce the probit (and logit) equations from which we compute the propensity scores that we use to form our comparison groups. This paper shows, moreover, that the main result reported by Persson holds with equal or greater force when his trade-based strategy is replaced by my country-based strategy.

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Table 1: Bilateral trade equations 1990

Variable	Rose	Rose revised	Country based treatment group A	Country based treatment group B
Constant	-22.5056	-22.5259	-21.5540	-22.0739
	(0.557)**	(0.567)**	(0.818)**	(0.856)**
Currency union	1.5086	1.7239	1.3798	1.2219
	(0.268)**	(0.310)**	(0.326)**	(0.305)**
Exchange rate variability	-0.0090	-0.0075	-0.0108	-0.0095
	(0.002)**	(0.002)**	(0.004)*	(0.004)*
Log output (i x j)	0.8251	0.8239	0.8314	0.8570
	(0.011)**	(0.011)**	(0.017)**	(0.018)**
Log output per capita (i x j)	0.7291	0.7357	0.6652	0.7071
	(0.023)**	(0.023)**	(0.029)**	(0.032)**
Distance	-1.1245	-1.1387	-1.1421	-1.2660
	(0.036)**	(0.039)**	(0.054)**	(0.059)**
Contiguity	0.6346	0.5869	1.2867	1.1321
	(0.179)**	(0.175)**	(0.297)**	(0.304)**
Common language	0.5003	0.6278	0.6648	0.6240
	(0.078)**	(0.077)**	(0.096)**	(0.099)**
Common FTA	0.6726	0.5852	1.2120	1.1368
	(0.144)**	(0.143)**	(0.269)**	(0.291)**
Same nation	0.8797	-0.3013	-0.0010	-----
	(0.517)	(0.814)	(0.844)	-----
Common coloniser	0.5881	0.4242	0.2741	0.3497
	(0.122)**	(0.126)**	(0.137)*	(0.140)*
Colonial relationship	1.7478	1.5829	1.6215	1.6062
	(0.147)**	(0.177)**	(0.205)**	(0.179)**
N	4239	4288	2879	2500
R-squared	0.7246	0.7196	0.5685	0.5874
RMSE	1.7454	1.7607	1.9154	1.8792
Trade raising effect of currency union (per cent)	352	461	297	239

OLS estimates; robust standard errors in parentheses
* Significant at 0.05 level
** Significant at 0.01 level

Table 2: Country based currency union probit equations 1990

Variable	Equation 1	Equation 2	Equation 3	Equation 3a
Constant	9.5322	8.9764	8.2710	8.6556
	(3.485)**	(3.100)**	(2.927)**	(3.608)*
Output per capita (log)	-0.5658	-0.5988	-0.5444	-0.4708
	(0.268)*	(0.214)**	(0.207)**	(0.238)*
Population (log)	-0.4794	-0.4378	-0.4420	-0.4947
	(0.148)**	(0.117)**	(0.112)**	(0.137)**
Ex colony	1.0849	1.0834	---	---
	(0.571)	(0.469)*		
Ex colony or dependency	---	---	1.2486	1.2964
			(0.468)**	(0.590)*
Export concentration	0.0103	0.0142	0.0226	0.0230
	(0.013)	(0.012)	(0.010)*	(0.013)
Openness	-0.0004	---	---	---
	(0.006)			
Member of FTA	0.1331	---	---	---
	(0.456)			
Island	-0.5871	---	---	---
N	138	140	148	121
Pseudo R squared	0.4378	0.4470	0.5080	0.5637
Log likelihood	-36.7075	-37.9640	-39.8262	-31.3512

Equation 1: All countries except 2 for which openness not available
Equation 2: All countries
Equation 3: All countries and dependencies
Equation 3a: All countries and dependencies included in bilateral data set

* Significant at 0.05 level
** Significant at 0.01 level

Table 3: Countries classified by estimated probabilities of entering a currency union, using country based probit equation for all included countries

Probability	Currency union countries	Other countries
0.0 to 0.0009	—	USA, India, China, Germany, UK, Japan, France, Italy, Brazil, Spain, Pakistan, South Africa, Argentina, Iran, Turkey, Thailand, Australia, Sweden, Egypt, Indonesia, Netherlands, Belgium-Luxembourg, Bangladesh, Switzerland, Poland, Portugal
0.001 to 0.009	—	Finland, Denmark, Chile, Greece, Philippines, Mexico, Norway, Hungary, Peru, Austria, New Zealand, Colombia, Venezuela, Canada, Syria, Sri Lanka, Israel, Vietnam
0.01 to 0.049	—	Ireland, Bolivia, Jordan, Uruguay, Guatemala, Ecuador, Paraguay, Malaysia, Nicaragua, El Salvador, Algeria
0.05 to 0.099	Panama	Hong Kong, Costa Rica, Morocco, Iceland, Sudan, Singapore
0.10 to 0.199	Ivory Coast	Kenya, Dominican Rep, Honduras, Nigeria, Zimbabwe, Tunisia, Mozambique, Laos

Probability	Currency union countries	Other countries
0.20 to 0.299	Cameroon, Mali	Uganda, Ghana, Malawi
0.30 to 0.399	Senegal, Burkina-Faso, Congo, Benin, Togo	Rwanda, Madagascar, Cyprus, Burundi, Guinea, Papua New Guinea, Zambia
0.40 to 0.499	Gabon, Barbados	Sierra Leone, Mauritius, Fiji
0.50 to 0.599	Chad	Trinidad & Tobago, Mauritania
0.60 to 0.699	Bahamas	—
0.70 to 0.799	New Caledonia	Guyana
0.80 to 0.899	Central African Rep, Equatorial Guinea, Guinea Bissau, Antigua & Barbuda, Grenada, Belize	Gambia, Seychelles
0.90 to 0.999	Reunion, Fr Guiana, Martinique, Guadeloupe, St Lucia, St Vincent & Grenadines, Dominica, Comoros, Nauru, St. Kitts & Nevis, Kiribati, Greenland, Montserrat, St. Pierre & Miquelon	—

Table 4: Characteristics of currency union and comparison group countries, using country based data sets

Variable	Number of countries	Log GDP	Log GDP PC	Log population	Openness	Export concentration
Using treatment group A:						
Mean for currency union countries	34	20.79	7.82	12.96	91.70	43.22
Mean for comparison group countries	32	22.71	7.44	15.26	86.05	30.50
Difference between means	---	-1.92	0.38	-2.30	5.65	12.72
t statistic for difference	---	5.32**	1.44	5.02**	0.35	2.72**
Using treatment group B:						
Mean for currency-union countries	19	21.63	7.38	14.24	82.14	29.75
Mean for comparison group countries	32	22.71	7.44	15.26	86.05	30.50
Difference between means	---	-1.08	-0.06	-1.02	-3.91	-0.75
t statistic for difference	---	2.98**	0.19	2.24*	0.21	0.19

NB: As estimates of openness are not available for two countries and seven dependencies, the number of countries used to calculate the currency union country means for that variable falls from 34 to 25 for treatment group A and from 19 to 18 for treatment group B; he reduction is smaller for the latter because one country and all of the dependencies are deleted from it.

* Significant at 0.05 level
** Significant at 0.01 level

Table 5: Means of bilateral trade flow for currency union and other country pairs, using country based data sets

Variable	Number of Countries	Number of Trade Flows	Log of Bilateral Trade Flow
Using comparison group A:			
Mean for currency union trade flows	34	63	8.11
Mean for other trade flows	32	2818	7.96
Difference between means	---	---	0.15
t statistic for difference	---	---	0.41
Using comparison group B:			
Mean for currency union trade flows	19	39	8.01
Mean for other trade flows	32	2463	8.10
Difference between means	---	---	-0.09
t statistic for difference	---	---	0.19

* Significant at 0.05 level
** Significant at 0.01 level

Table 6: Means of bilateral trade flows and other characteristics of currency union and comparison group country pairs, using trade-based (Persson type) data sets

Variable	Number of country pairs	Log product GDP	Log product GDP PC	Log product population	Log bilateral trade flow
Stratification method:					
Mean for currency union country pairs	63	28.73	15.77	12.96	8.11
Mean for comparison group country pairs	1429	32.77	15.79	16.98	7.55
Difference between means	---	-4.04	-0.01	-4.02	0.56
t statistic for difference	---	12.50**	0.10	10.93**	1.42
Nearest-matching method:					
Mean for currency union country pairs	63	28.73	15.77	12.96	8.11
Mean for comparison-group country pairs	32	29.08	15.81	13.27	7.22
Difference between means	---	-0.35	-0.03	-0.31	0.90
t statistic for difference	---	0.48	0.09	0.72	1.44

* Signficant at 0.05 level
** Significant at 0.01 level

Table 7: Bilateral trade equations 1990 using trade based (Persson type) data sets

Variable	Stratification method	Nearest matching method
Constant	-15.5698	-19.5249
	(1.202)**	(5.636)**
Currency union	1.0328	0.8702
	(0.347)**	(0.611)
Exchange rate variability	-0.0067	-0.0021
	(0.004)	(0.020)
Log output (i x j)	0.6824	0.9236
	(0.021)**	(0.117)**
Log output per capita (i x j)	0.5646	0.2349
	(0.045)**	(0.206)
Distance	-1.1052	-0.7695
	(0.065)**	(0.177)**
Contiguity	1.0779	1.5843
	(0.209)**	(0.660)*
Common language	0.8574	0.0716
	(0.116)**	(1.235)
Common FTA	0.7674	2.3223
	(0.242)**	(0.793)**
Same nation	0.0658	1.3816
	(0.930)	(0.920)
Common coloniser	0.2010	0.4360
	(0.136)	(0.981)
Colonial relationship	2.1788	-1.5005
	(0.231)**	(2.750)
N	1492	95
R squared	0.6173	0.6415
RMSE	1.8946	1.8399
Trade-raising effect of currency union (per cent)	181	139

OLS estimates; robust standard errors in parentheses
* Significant at 0.05 level
** Significant at 0.01 level

Table A1: Country list

113 Countries included in revised bilateral data set

Algeria	Antigua & Barbuda	Argentina	Australia
Austria	Bahamas*	Bangladesh	Barbados
Belgium Luxembourg	Belize	Benin	Bolivia
Brazil	Burkina-Faso	Burundi	Cameroon
Canada	Central African Rep	Chad	Chile
China	Colombia	Comoros	Congo
Costa Rica	Cyprus	Denmark	Dominica
Dominican Rep	Ecuador	Egypt	El Salvador
Equatorial Guinea	Fiji	Finland	France
Gabon	Gambia	Germany	Ghana
Greece	Grenada	Guatemala	Guinea
Guinea-Bissau	Guyana	Honduras	Hong Kong
Hungary	Iceland	India	Indonesia
Iran	Ireland	Israel	Italy
Ivory Coast	Japan	Jordan	Kenya
Kiribati	Laos	Madagascar	Malaysia
Malawi	Mali	Mauritania	Mauritius
Mexico	Morocco	Mozambique	Nauru*
Netherlands	New Zealand	Nicaragua	Nigeria
Norway	Pakistan	Panama	Papua New Guinea
Paraguay	Peru	Philippines	Poland
Portugal	Rwanda	St Kitts & Nevis	St Lucia
St Vincent & Grenadines	Senegal	Seychelles	Sierra Leone
Singapore	South Africa	Spain	Sri Lanka
Sudan	Sweden	Switzerland	Syria
Thailand	Togo	Trinidad & Tobago	Tunisia
Turkey	Uganda	United Kingdom	United States
Uruguay	Venezuela	Vietnam	Zambia
Zimbabwe			

8 Dependencies [colonies or political subdivisions] included in revised bilateral data set

French Guiana	Greenland	Guadeloupe	Martinique
Montserrat	New Caledonia	Reunion	St Pierre & Miquelon

27 Countries not included in revised bilateral data set but added to country data set

Angola	Bulgaria	Cambodia	Cape Verde
Czechoslovakia	Ethiopia	Haiti	Jamaica
Korea	Lebanon	Macau	Maldives
Malta	Mongolia	Nepal	Niger
Romania	Saudi Arabia	Solomon Islands	Suriname
Taiwan	Tanzania	United Arab Emirates	Vanuatu
Yemen	Yugoslavia	Zaire	

* Omitted from country probit equations using openness as a regressor

Table A2: Correlation matrix for revised Rose data set

	Trade	Currency union	Exchange rate variability	Log output	Log output per capita	Distance	Contiguity	Common language	Common FTA	Same nation	Common coloniser	Colonial relationship
Trade	1.000											
Currency union	-0.035	1.000										
Exchange rate variability	-0.114	-0.092	1.000									
Log output	0.698	-0.257	0.034	1.000								
Log output per capita	0.494	-0.066	-0.250	0.270	1.000							
Distance	-0.205	-0.253	0.073	0.198	-0.003	1.000						
Contiguity	0.155	0.065	0.039	0.039	-0.042	-0.338	1.000					
Common language	0.001	0.220	-0.037	-0.219	-0.082	-0.200	0.123	1.000				
Common FTA	0.174	0.202	-0.045	-0.085	0.128	-0.448	0.191	0.165	1.000			
Same nation	-0.010	0.452	-0.044	-0.098	0.055	-0.013	-0.009	0.119	0.030	1.000		
Common coloniser	-0.145	0.237	-0.074	-0.308	-0.211	-0.175	0.044	0.446	0.149	0.010	1.000	
Colonial relationship	0.122	0.017	-0.037	0.050	0.035	-0.013	-0.004	0.196	-0.014	0.090	-0.038	1.000

Table A3: Countries classified by estimated probabilities of entering a currency union, using country based probit equation for all countries

Probability	Currency Union Countries	Other Countries
0.0 to 0.009	—	USA, Germany, UK, Japan, France, Italy, India, China, Brazil, Spain, Australia, Sweden, South Africa, Argentina, *Romania*, *Korea*, Pakistan, Turkey, Iran, Thailand, Netherlands, Belgium-Luxembourg, Switzerland, Egypt, *Yugoslavia,* Finland, *Taiwan*, Portugal, Denmark, Indonesia, *Bulgaria*, Poland, Greece, Bangladesh, Chile, Norway, New Zealand, Austria, *Czechoslovakia*, Hungary, Mexico, Canada, Peru, Philippines, Israel, Venezuela, Colombia, Syria, Sri Lanka, Ireland, *Ethiopia*, Vietnam, *Zaire*
0.01 to 0.049	—	Uruguay, *Saudi Arabia*, Jordan, *Tanzania*, Bolivia, Guatemala, *Lebanon*, Ecuador, Malaysia, Paraguay, *Nepal*, Nicaragua, El Salvador, Algeria, Hong Kong, Iceland, *Mongolia*, *Cambodia*, Costa Rica, *Angola*, *Yemen*
0.05 to 0.099	Panama	Singapore, Morocco, *United Arab Emirates*, Dominican Rep, Sudan, Honduras, Kenya

Probability	Currency Union Countries	Other Countries
0.10 to 0.199	Ivory Coast	Tunisia, Zimbabwe, Nigeria, Laos, Mozambique, *Suriname*
0.20 to 0.299	Cameroon, Mali, Senegal, Congo	Cyprus, Uganda, Ghana, *Cape Verde Islands*, *Jamaica,* Malawi, Rwanda, Madagascar, *Macau*
0.30 to 0.399	Benin, Barbados, Burkina Faso, Gabon, Togo	Mauritius, Papua New Guinea, Guinea, Burundi, Fiji, Zambia, Sierra Leone, Trinidad & Tobago, *Malta*
0.40 to 0.599	Bahamas, Chad, New Caledonia, *Niger*	Mauritania, *Maldives*
0.60 to 0.799	Antigua & Barbuda, Equatorial Guinea, Grenada, Guinea Bissau, Belize, Central African Rep	*Haiti*, Guyana, *Vanuatu*, Seychelles, *Solomon Islands*, Gambia
0.80 to 0.999	Fr Guiana, Martinique, Reunion, Guadeloupe, St Lucia, Dominica, St Vincent & Grenadines, Nauru, Comoros, St Kitts & Nevis, Greenland, Montserrat, St Pierre & Miquelon, Kiribati	—

Countries listed in italics are those not covered by the bilateral trade data.

Table A4: Trade based currency union equations

Variable	Persson All years (Logit)	New 1990 (Probit)
Constant	na ---	10.532 (2.696)**
Output (log)	- 0.240 (0.033)**	-0.183 (0.048)**
Output per capita (log)	-0.168 (0.058)**	-0.227 (0.098)*
Distance	-1.016 (0.088)**	-0.542 (0.088)**
Contiguity	-0.390 (0.278)	-0.031 (0.313)
Common language	1.743 (0.208)**	1.017 (0.203)**
Common FTA	-1.431 (0.292)**	-0 467 (0.342)
Same nation	6.246 (0.546)**	4.422 (0.747)**
Common coloniser	1.401 (0.203)**	0 309 (0.177)
Colonial relationship	-1.817 (0.695)**	--- ---
N	26607	4288
Pseudo R squared	0.489	0.648

* Significant at 0.05 level
** Significant at 0.01 level

Table A5: Country pairs classified by estimated probabilities that they share a common currency, using trade based data set

Probability	Number of currency union country pairs	Number of other country pairs
Less than 0.00015	0	2796
0.00015 to 0.0099	2	1102
0.01 to 0.049	4	176
0.05 to 0.099	4	52
0.10 to 0.149	3	42
0.15 to 0.199	3	19
0.20 to 0.299	5	16
0.30 to 0.399	4	10
0.40 to 0.499	10	9
0.50 to 0.599	2	1
0.60 to 0.699	3	1
0.70 to 0.799	7	0
0.80 to 0.899	5	0
0.90 to 0.949	1	1
0.95 to 0.999	10	0
Total	63	4225
Total included	63	1429